REMARKS

This paper is being provided in response to the Final Office Action mailed September 7, 2004, for the above-referenced application. In this response, Applicants have added new claim 22 and amended claims 1, 7, 10, 16, 17 and 21 to clarify that which Applicants consider to be the invention. Applicants respectfully submit that the new claim and the amendments to the claims are fully supported by the originally-filed specification.

Applicants thank the Examiner for allowing claims 8, 9 and 18-20 and for the indication of allowable subject matter in claim 6.

The objection to claim 16 for informalities has been addressed by amendments contained herein in accordance with the guidelines as set forth in the Office Action. Accordingly, Applicants respectfully request that this objection be reconsidered and withdrawn.

The rejection of claims 1-5, 7, 15-17 and 21 under 35 U.S.C. 102(b) as being anticipated by U.S. Patent No. 4,422,060 to Matsumoto et al. (hereinafter "Matsumoto") and the rejection of claim 10 under 35 U.S.C. 103(a) as being unpatentable over Matsumoto are hereby traversed and reconsideration is respectfully requested in view of the amendments to the claims contained herein.

Independent claim 1, as amended herein, recites an electromagnetic actuator. The actuator includes a stationary assembly includes a hollow stator yoke composed of a soft magnetic material and two coils disposed coaxially and separately in a traveling direction of the

actuator inside the hollow stator yoke. A movable assembly is disposed in a hollow space of the two coils to oppose thereto with a very small clearance. The movable assembly includes a movable magnetic unit and a movable yoke unit, both units mounted on a single supporting shaft adjacently to each other in an axial direction of the supporting shaft. The movable assembly travels in the axial direction by an electromagnetic force generated with the coils by the interaction between a magnetic field generated by the movable magnetic unit and current flowing in the coils. The moveable magnet unit is disposed on said single support shaft so as to oppose said coils radially. Claims 2-6 and 15-16 depend directly or indirectly on independent claim 1.

Independent claim 7, as amended herein, recites an electromagnetic actuator. A stationary assembly includes two coils disposed coaxially with each other inside a hollow stator yoke composed of a soft magnetic material. A movable assembly includes a movable magnet unit and a movable yoke unit both disposed inside the coils with a very small clearance therefrom and both attached to a single supporting shaft such that the movable assembly is movable in the axial direction of the supporting shaft. The movable assembly travels in the axial direction by an electromagnetic force generated with the coils by the interaction between a magnetic field generated by the movable magnet unit and a current passing through the coils, and wherein the movable magnet unit is disposed on the single supporting shaft so as to opposed the coils radially. The two coils are wound on respective separate bobbins made of a synthetic resin and having a substantially identical shape with each other and are disposed axially inside the stator yoke with a predetermined distance provided therebetween. The stator yoke of the stationary assembly is a hollow cylinder and the two coils are ring-shaped and wound on the respective cylindrical bobbins. The movable assembly has a supporting shaft at the center

thereof and the movable yoke unit is located such that the movable yoke unit and the two coils effect electromagnetic action on each other. A pair of flanges are provided at both axial end surfaces of the stator yoke, each flange having a bearing mechanism, and the supporting shaft is retained by the bearing mechanisms so as to be movable in the axial direction. The movable magnet unit of the movable assembly is formed of at least one columnar of hollow magnet axially magnetized with two opposite polarities. The movable yoke unit is constituted by a pair of soft magnetic members that have a substantially identical configuration with each other and are disposed to sandwich the movable magnet unit and to abut against a north-pole end surface and a south-pole end surface thereof. The outer diameter of the movable magnet unit of the movable assembly is set to be smaller than the outer diameter of the movable yoke unit.

Independent claim 10, as amended herein, recites an electromagnetic actuator. The actuator includes a stationary assembly that includes a hollow stator yoke composed of a soft magnetic material and a plurality of paired coils each of which is composed of two coils disposed separately in a traveling direction of the actuator inside the hollow stator yoke. A movable assembly includes the same number of pairs of a movable magnet unit and a movable yoke unit as the number of the paired coils and is disposed in a hollow space of the paired coils to oppose thereto with a very small distance. The movable assembly is mounted on a single supporting shaft such that the movable assembly is movable in the axial direction of the supporting shaft. The movable assembly travels in the axial direction by an electromagnetic force generated with the coils by the interaction between a magnetic field generated by the movable magnet unit and a current flowing in the paired coils. The moveable magnet unit is disposed on said single support shaft so as to oppose said coils radially.

Independent claim 17, as amended herein, recites an electromagnetic actuator. A stationary assembly includes two coils disposed coaxially with each other inside a hollow stator yoke composed of a soft magnetic material. A movable assembly includes a movable magnet unit and a movable yoke unit both disposed inside the coils with a very small clearance therefrom and both attached to a single supporting shaft such that the movable assembly is movable in the axial direction of the supporting shaft. The movable assembly travels in the axial direction by the interaction between a magnetic field generated by the movable magnet unit and a current passing through the coils. The movable magnet unit is disposed on the single supporting shaft so as to opposed the coils radially.

Independent claim 21, as amended herein, recites an electromagnetic actuator. A stationary assembly includes a hollow stator yoke composed of a soft magnetic material and two coils disposed coaxially and separately in a traveling direction of the actuator inside the stator yoke. A movable assembly is disposed in a hollow space of the two coils to oppose thereto with a very small clearance. The movable assembly includes a movable magnet unit and a movable yoke unit, both units mounted on a single supporting shaft adjacently to each other in an axial direction of the supporting shaft. The movable assembly travels in the axial direction by an electromagnetic force generated with the coils by the interaction between a magnetic field generated by the movable magnet unit and a current flowing in the coils, and wherein the movable magnet unit is disposed on the single supporting shaft so as to oppose the coils radially.

The outer diameter of the movable magnet unit of the movable assembly is set to be smaller than the outer diameter of the movable yoke unit.

The Mastumoto reference discloses a DC electromagnetic actuator in which a direct current is supplied such that an S pole appears at a portion 32c of a center yoke 32, while N poles appear on portions 37'a and 37'b of end yokes 37a and 37b facing the center yoke 32. As a result, a magnetic repulsive force acts between a magnetic member 55a and the portion 37'a, while a magnetic attracting force acts between a magnetic member 55b and the portion 37'b, so that a moving means 5 is moved in a direction indicated by an arrow X of solid line shown in Figure 2. (See col. 4, lines 21-45 of Matsumoto.)

Applicants' independent claims, as amended herein, recite at least the features of an electromagnetic actuator having a movable assembly disposed in a hollow space of two coils that includes a movable magnet unit and a movable yoke unit, both units mounted on a single supporting shaft adjacently to each other in an axial direction of the supporting shaft, wherein the movable assembly travels in the axial direction *by an electromagnetic force generated with the coils by the interaction between a magnetic field generated by the movable magnet unit and a current flowing in the coils*, and wherein the movable magnet unit is disposed on the single supporting shaft so as to oppose said coils radially. The actuator of the present claimed invention operates according to Fleming's left hand rule applied to the mutual action between the magnetic field produced by the movable magnet unit and the current flowing in the coils. (See, for example, page 13, line 6 to page 15, line 4 of the present application). In this way, the movable assembly can be brought to its target position by monitoring the current position of the

movable assembly relative to the target position and continuously changing the direction and value of current according to the monitoring.

One example of a device, and its operation, according to the present claimed invention is shown in Figure 2A of the present application. Coil 12b is subjected to an electromagnetic force in the direction indicated by an arrow F1 according to Fleming's left-hand rule. However, the coil 12b is secured on an inner surface of a stator yoke 11 so that a movable yoke 22 is subjected to the force F1 in the opposite direction due to reaction. In the same way, coil 13b is subjected to an electromagnetic force in the direction indicated by an arrow F2, and a movable yoke 23 is subjected to the force F2 in the opposite direction as a reaction. As a result, a movable assembly 2 is subjected to a force F (F = F1 + F2). Therefore the movable assembly 2 travels in an axial direction by the electromagnetic force generated with the coils 12b and 13b by the interaction between a magnetic field generated by a movable magnet unit 21 and a current flowing in the coils 12b and 13b when coils 12b and 13b are magnetized.

In contrast, as noted above in the description of the Matsumoto reference, Matsumoto's movable means 5 is moved in the axial direction by magnetic repulsive and attracting forces resulting from the generated appearance of N and S poles at locations on the end yokes and center yokes that repulse or attract the magnetic member 55, and not by an *electromagnetic force generated with the coils by the interaction between a magnetic field generated by the movable magnet unit and a current flowing in the coils*, as is claimed by Applicant. Thus, Matsumoto does not disclose an actuator that operates based on the generation of an electromagnetic force,

as is claimed by Applicant, and instead relies a different principle of operation concerning magnetic repulsive and attracting forces between the center/end yokes and the magnetic member.

Accordingly, Applicants respectfully submit that Matsumoto does not teach or fairly suggest at least the above-noted features as claimed by Applicants. In view of the above, Applicants respectfully request that the rejections over Matsumoto be reconsidered and withdrawn.

Further, Applicants have added new dependent claim 22, that depends from independent claim 1, and respectfully submits that this claim is patentable over the prior art of record.

Based on the above, Applicant respectfully requests that the Examiner reconsider and withdraw all outstanding rejections and objections. Favorable consideration and allowance are earnestly solicited. Should there be any questions after reviewing this paper, the Examiner is invited to contact the undersigned at 617-248-4038.

Respectfully submitted,
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